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Mollusc survey of the lower Bruneau River, Owyhee County, Idaho, U.S.A.

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Abstract: The Bruneau River in southwestern Idaho is a largely free-flowing desert stream characterized by a snowmelt-driven hydrograph, flash floods, and geothermal inputs. We surveyed the lower Bruneau River from its confluence with the Snake River upstream to Hot Creek, a distance of approx. 41 river kilometers, between 1997 and 2008. We supplemented our work with a review of collections held at the Orma J. Smith Museum of Natural History, College of Idaho and with collections available online from national and international museums. The known mollusc fauna consists of 18 species (11 gastropods and 7 bivalves) from eight families. Molluscan richness is greatest in free-flowing stream reaches and is dominated by hydrobiid and unionid taxa.

Key words: gastropods, bivalves, invasive species

The freshwater molluscan fauna of Idaho has interested malacologists for many years (Hendersen 1924) yet its diverse taxa remain poorly understood (Frest and Johannes 2000, Frest *et al.* 2001). Further, the taxonomic status of some species in Idaho is under revision (Taylor 2003, Hershler and Liu 2004, Rogers and Wethington 2007, Wethington and Lydeard 2007) with considerable work yet to be completed. Of the 117 putative species in Idaho (Frest and Johannes 2000), few published accounts exist on their occurrence in specific stream segments. Similarly, the ecology of most gastropods, including species in Idaho, has received very little attention (Brown *et al.* 2008) resulting in a vague understanding of interactions between species and their environment. Conservation of freshwater molluscs requires: (1) an understanding of the relationships between species in a geographic area (*i.e.*, stabilized taxonomy), (2) an understanding of the distribution of species (*i.e.*, species inventory), and (3) an understanding of the ecology of species within the context of long-term species persistence (Brown and Johnson 2004, Stewart and Dillon 2004, Lysne *et al.* 2008). In reality, natural resource managers must frequently prioritize conservation goals with incomplete biological knowledge (Regan *et al.* 2003, 2005). Within this context, we join other efforts (Dillon 2008) to document molluscan biodiversity and to provide information for natural resource managers to set conservation priorities.

MATERIALS AND METHODS

Study area

The Bruneau River, in southwestern Idaho, is a largely free-flowing, high-desert stream originating in the mountains of northern Nevada and stretching approx. 185 km north to join the Snake River (Fig. 1). Only two known structures divert Bruneau River water between the Bruneau Arm and its headwaters: Buckaroo Diversion at Bruneau River kilometer (RKM) 34 and Harris Diversion at RKM 34.4. Mean instantaneous flow of the Bruneau River, measured at RKM 35.4 between 1987 and 2007 was 8.47 cubic meters second^{-1} (cms) and ranged from 2.86 cms in December to 30.58 cms in May (USGS 2008). Mean monthly water temperatures ranged from 14 °C in May to 21 °C in September, with a high of 26 °C in August (USGS 2008). The Bruneau River has few perennial tributaries but has numerous ephemeral creeks that can significantly increase flow during intense summer storms. A defining characteristic of the Bruneau River system is the geothermal aquifer that underlies much of southern Idaho (Berenbrock 1993) and contributes a base flow to the river year round. Water temperature of geothermal spring flows range between 11 °C and 40 °C (Myler *et al.* 2007), and an abrupt thermocline has been observed in the main channel as a result of geothermal, hyporheic additions to the river.

Field sampling

We surveyed sections of the Bruneau River from the Bruneau Arm of C. J. Strike Reservoir (*i.e.*, the confluence of the Bruneau and Snake Rivers; 42.92375°N, 115.90353°W) to Hot Creek (42.76226°N, 115.73084°W), a distance of approx. 41 km (Fig. 1). We used a Venturi dredge apparatus and SCUBA (Stephenson *et al.* 2004) to collect 432 samples from the Bruneau Arm of C. J. Strike Reservoir. A 0.25-m^2 quadrat was placed on the reservoir bottom and the substrate suctioned to a depth of approx. 5 cm. Samples were sorted by hand to identify, and return to the river, endangered gastropod species, if present. Remaining sample material was

preserved in 95% ETOH and shipped to EcoAnalysts Inc., Moscow, Idaho, for identification to the lowest possible taxonomic level. We estimated densities of taxa for species importance curves based on all collections between 1997 and 2008 where density information was available.

In the free-flowing reaches of the Bruneau River, we conducted visual inspections (via a benthic viewer) of all available habitat types (*e.g.*, springs, river, pools, riffles, submerged and emergent aquatic vegetation, fines, cobbles, and bedrock) below Hot Creek. We spent more than 100 person-hours surveying the stream and associated habitats for molluscs. We used hand collections only in the river below Hot Creek and made no attempt to quantify densities or total numbers of individuals of any taxa. Relative abundance of taxa for species importance curves was estimated qualitatively by professional judgment. We collected and preserved individuals in 95% ETOH only for purposes of voucher specimens. These individuals were identified to the lowest possible taxonomic level. Collections in the Bruneau Arm occurred throughout the year but our observations in the free-flowing Bruneau River were conducted, for safety reasons, between July and March when flows were <5.7 cms. Available information including approximate sample locations, physico-chemical data, and lists of non-molluscan taxa are available from the authors.

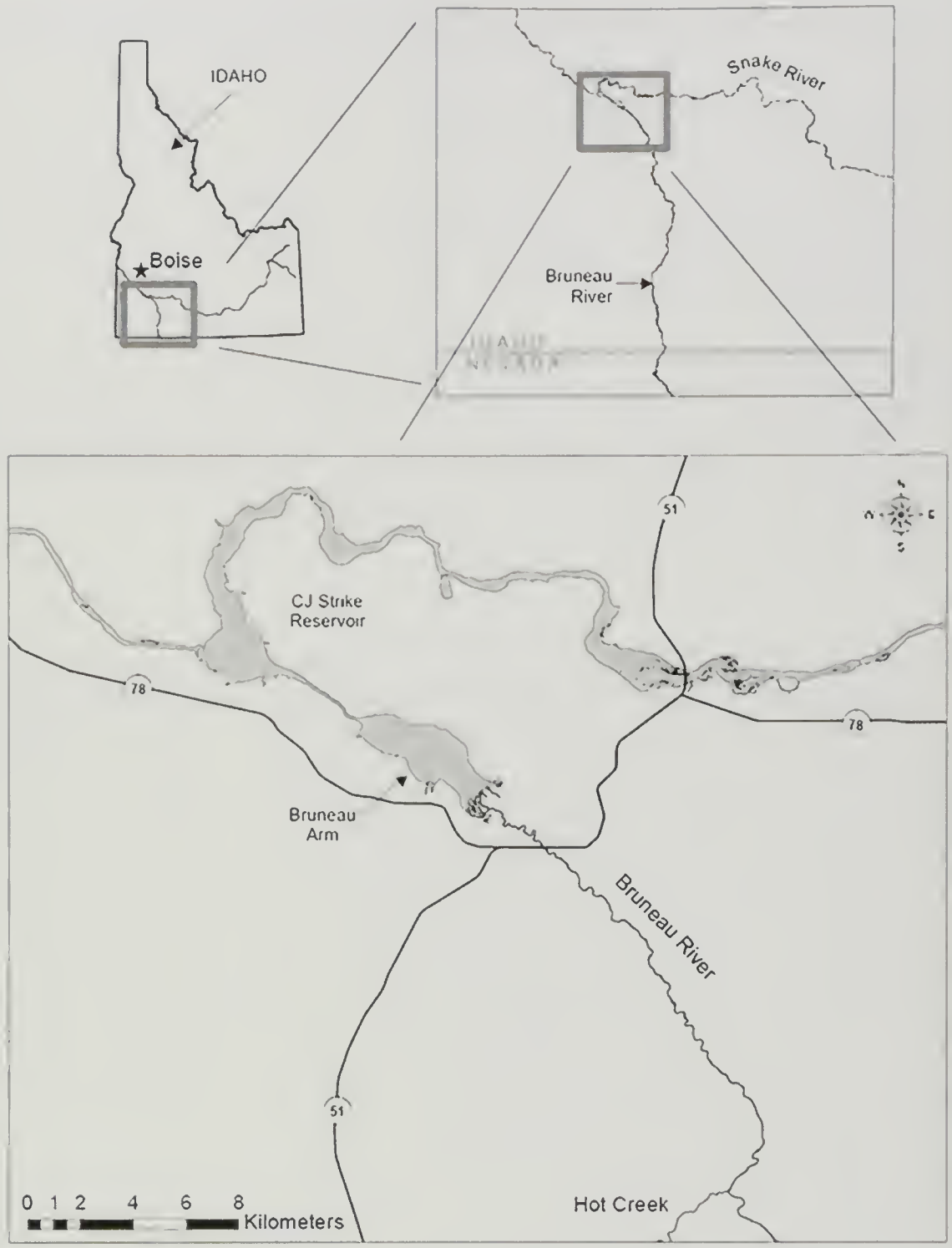

Figure 1. Figure of the study area in southwestern Idaho. Samples were observed or collected in the Bruneau Arm as well as the Bruneau River between Hot Creek and Highway 51.

Museum collections

We supplemented our work with a review of collections held at the Orma J. Smith Museum of Natural History, The College of Idaho (http://www.collegeofidaho.edu) between August 2007 and September 2008. The Smith Museum houses the largest collection of freshwater molluscs in Idaho and has staff dedicated to the curation and study of freshwater molluscs. We conducted a query of the Smith Museum's curation database resulting in approx. 1,100 lots from the Bruneau River. We also inspected approx. 150 un-cataloged lots of freshwater molluscs, looking for collections from the Bruneau River. In addition, we surveyed online databases and/or requested searches from The University of Michigan's Museum of Zoology, the California Academy of Sciences, and The Canadian Museum of Nature. From these searches, we obtained 418 lots containing molluscs from the Bruneau River. Detailed information on all collections is available from the authors. Voucher specimens from our work have been deposited at the Orma J. Smith Museum of Natural History. Identifications followed Burch (1989); nomenclature follows Turgeon *et al.* (1998) for most taxa and Mackie (2007) for the corbiculid and sphaeriid clams.

RESULTS

We documented eleven species of gastropods from five families, including the endangered, thermophillic springsnail *Pyrgulopsis bruneauensis* (Hershler, 1990) (Myler *et al.* 2007) and two non-native gastropods: *Potamopyrgus antipodarum* (Gray, 1853) and *Radix auricularia* (Linnaeus, 1758). We also documented seven species of bivalve molluscs from three families, including the invasive *Corbicula fluminea* (Müller, 1774). Table 1 lists species collected or observed, the location of collection, and information on the conservation status of each taxon globally and in Idaho (NatureServe 2008). Thirteen species of molluscs were collected or observed in the free-flowing reaches of the Bruneau River below Hot Creek. Of these molluscs, one hydrobiid gastropod, *Fluminicola fuscus* (Haldeman, 1847), and one unionid bivalve, *Gonidea angulata* (Lea, 1838), dominated numerically. Nine species of molluscs were collected from the impounded Bruneau Arm of C. J. Strike Reservoir. Of these, *Gyraulus parvus* (Say, 1817) and *Vorticifex effusa* (Lea, 1856) dominated numerically. Four species were found in both the free-flowing sections of the river and the reservoir and all are considered habitat generalists. The three non-native species (*C. fluminea*, *P. antipodarum*, and *R. auricularia*) occurred in the river and reservoir reaches.

We observed a change in species importance from reservoir to river habitats (Figs. 2A-B). Based on our collections, the Bruneau Arm molluscan community is dominated by *Vorticifex effusa* and *Gyraulus parvus*. Estimated densities of both species exceeded 1,500 individuals/m^2 whereas estimated densities for all other taxa fell below 400 individuals/m^2. By contrast, in the river below Hot Creek the molluscan community is dominated by *Fluminicola fuscus* and *Gonidea angulata*. Three additional species, *Gyraulus parvus*, *Physa gyrina*, and *Pyrgulopsis bruneauensis*, represented an intermediate relative abundance with the remaining taxa best described as uncommon.

DISCUSSION

The molluscan fauna of the Bruneau River below Hot Creek is rich (containing about 15% of the known Idaho fauna) relative to other tributaries of the Snake River in southern Idaho. The reasons for this diversity are not entirely known, but the relatively long length of the stream at the landscape scale, the diversity of habitats at multiple spatial scales, water chemistry, geothermal influences, and the relatively unimpaired conditions of the Bruneau River corridor are probably important influences.

Table 1. Molluscs present in the lower Bruneau River (below Hot Creek), Idaho. Data show presence related to general habitat as well as conservation status. Voucher specimens of each taxon are located in the Orma J. Smith Museum of Natural History, The College of Idaho. Habitat descriptors: RIV, river; RES, reservoir. Rankings are from NatureServe (2008): G1/S1, critically imperiled; G2/S2, imperiled; G3/S3, vulnerable; G4/S4, apparently secure; G5/S5, secure; SNR, state not ranked; EXO, exotic/introduced; NA, no ranking available.

Family	Genus	Species	Authority	Habitat	G Rank	S Rank
Gastropods						
Ancylidae	*Ferrissia*	*rivularis*	Say, 1817	RIV, RES	G5	SNR
Hydrobiidae	*Fluminicola*	*fuscus*	Haldeman, 1847	RIV	G2	S1
Hydrobiidae	*Potamopyrgus*	*antipodarum*	Gray, 1853	RIV, RES	G5	EXO
Hydrobiidae	*Pyrgulopsis*	*bruneauensis*	Hershler, 1990	RIV	G1	S1
Hydrobiidae	*Pyrgulopsis*	*robusta*	Walker, 1908	RES	G4	S1
Lymnaeidae	*Fossaria*	sp.	Westerlund, 1885	RES	NA	NA
Lymnaeidae	*Radix*	*auricularia*	Linnaeus, 1758	RIV	G5	EXO
Physidae	*Physa*	*gyrina*	Say, 1821	RIV, RES	G5	SNR
Planorbidae	*Gyraulus*	*parvus*	Say, 1817	RIV, RES	G5	SNR
Planorbidae	*Planorbella*	*subcrenata*	Carpenter, 1857	RIV	G5	SNR
Planorbidae	*Vorticifex*	*effusa*	Lea, 1856	RES	G3	SNR
Bivalves						
Corbiculidae	*Corbicula*	*fluminea*	Müller, 1774	RES	G5	EXO
Sphaeriidae	*Pisidium*	*casertanum*	Poli, 1791	RIV	G5	SNR
Sphaeriidae	*Pisidium*	*variabile*	Prime, 1852	RIV	NA	SNR
Sphaeriidae	*Pisidium*	*compressum*	Prime, 1852	RES	G5	SNR
Sphaeriidae	*Sphaerium*	*simile*	Say, 1817	RIV	G5	SNR
Unionidae	*Anodonta*	*californiensis*	Lea, 1852	RIV	G5	SNR
Unionidae	*Gonidea*	*angulata*	Lea, 1838	RIV	G3	SNR

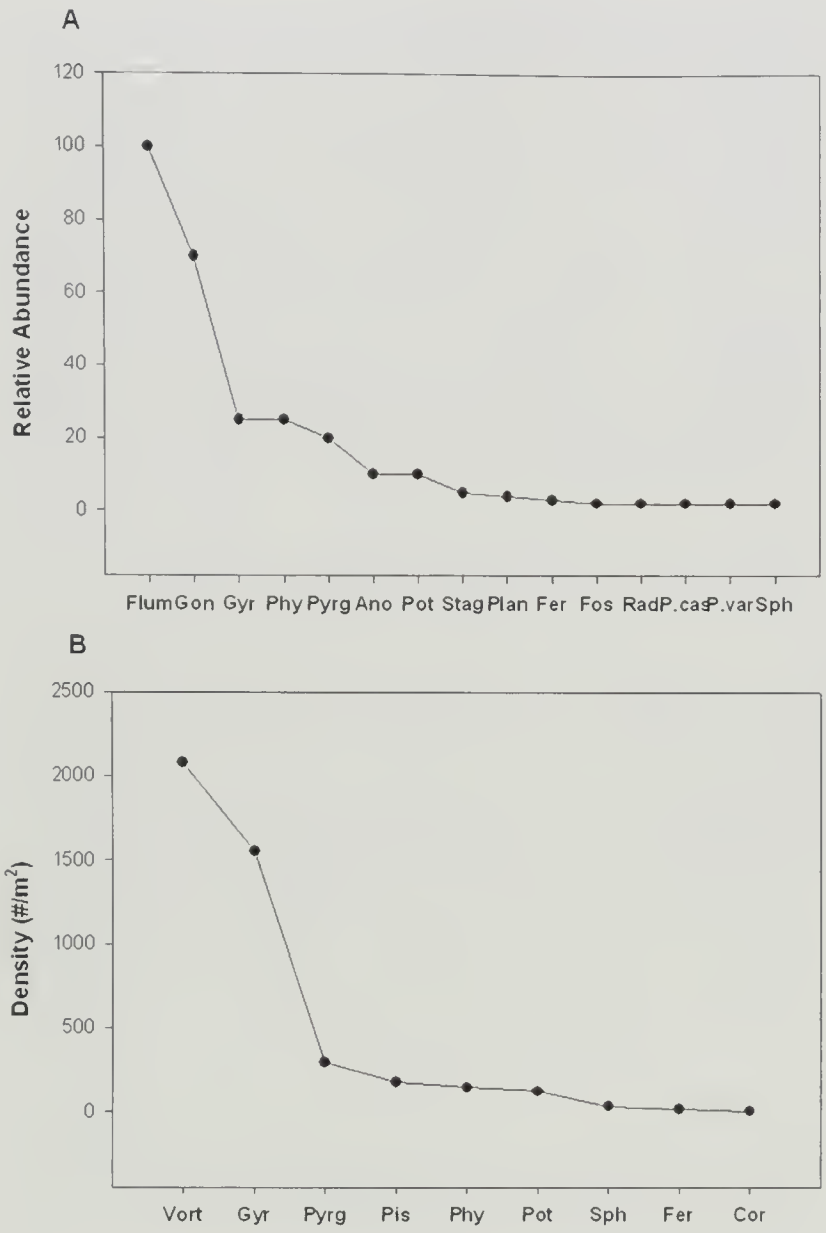

Figure 2. Importance curves for molluscs in the Bruneau River from Hot Creek to the Bruneau Arm of C. J. Strike Reservoir (A), and in the Bruneau Arm of C. J. Strike Reservoir (B). Abbreviations are: **Flum***inicola fuscus*, **Gon***idea angulata*, **Gyr***aulus parvus*, **Phy***sa gyrina*, **Pyrg***ulopsis bruneauensis* (A), **Ano***donta californiensis*, **Pot***amopyrgus antipodarum*, **Stag***nicola hinkleyi*, **Plan***orbella subcrenatum*, **Fer***rissia rivularis*, **Fos***saria* sp., **Rad***ix auricularia*, **P***isidium* **cas***ertanum*, **P***isidium* **var***iabile*, **Sph***aerium simile* (A), **Vort***icifex effusa*, **Pyrg***ulopsis robusta* (B), **Pis***idium compressum*, **Sph***aerium* sp. (B), and **Cor***icula fluminea*.

The Bruneau River is a long (ca. 185 km) desert stream. It is generally larger, in terms of volume, than most tributaries in southern Idaho but is considerably smaller than the Boise, Payette, or Salmon Rivers further to the north. The underlying basalt geology (Ross and Savage 1967) permits the Bruneau to run relatively clean without the excessive sedimentation that is observed in many desert streams. Further, much of the Bruneau River runs through remote canyon-lands with steeply incised walls that limit grazing and other activities that tend to result in increased sedimentation (Allan 1995, Belsky *et al.* 1999). Similarly, the Bruneau River above our study area lacks irrigation diversions, intensive agriculture, or timber harvest practices that are typical of many landscapes surrounding Idaho streams to the east and north. The result is a desert stream system unique in Idaho with a natural flow regime and a relatively undisturbed stream corridor.

The Bruneau River has a steep gradient as it leaves the Owyhee Uplands which begin to attenuate below Hot Creek. As the river approaches the town of Bruneau, Idaho, the topography flattens out and the river begins to meander, which reduces stream velocity and sediment load and alters benthic habitat. As the river continues toward the Bruneau Arm of C. J. Strike Reservoir, it bisects a large wetland created by the impoundment of the Snake and Bruneau Rivers. The Bruneau Arm is essentially lentic and different ecologically from the river upstream with a very different species assemblage. These varied landscape scale habitat characteristics may explain the high molluscan diversity in the Bruneau River (Newton *et al.* 2008).

Perhaps more importantly, the Bruneau River below Hot Creek has increased habitat heterogeneity owing to the geothermal aquifer that underlies much of the Owyhee Uplands in southern Idaho. Water temperature is perhaps one of the most important determinants of where species are presently found (Allan 1995), it has important implications with regard to a species biology (Brown *et al.* 1998, Lysne and Koetsier 2006a), and can be used as a predictor of species presence (Malcom and Radke 2005). Hundreds of geothermal springs enter the Bruneau along its length (Myler *et al.* 2007), both above and below the water's surface, creating a patchwork of different habitats, thermal characteristics, and floral and faunal assemblages. The geothermal aquifer also moderates cold winter temperatures and provides thermal refugia for aquatic invertebrates eliminating the need for hibernation-like, overwintering behaviors observed in other Idaho molluscs (Lysne and Koetsier 2006b). For example, water temperature in the Bruneau River measured at 2/3 depth in February of 2008 was 4.8 °C, below the known thermal range of *Pyrgulopsis bruneauensis* (Mladenka and Minshall 2001). However, at the boundary layer, water temperature was 12.7 °C, within the thermal tolerance of the species, and the river supports *P. bruneauensis* activity year-round given the appropriate substrates (Myler *et al.* 2007). Other species may respond similarly to the unusual thermal regime: Richards (2004) found populations of *Taylorconcha serpenticola* to fluctuate seasonally but reproduction occurred in winter with the thermally constant water temperatures. Similarly, Mladenka and Minshall (2001) found that *Pyrgulopsis bruneauensis* reproduced year-round in super-heated springs. Thus, the varied geothermal habitat characteristics, at a smaller spatial scale than the landscape, may also contribute to the high molluscan diversity of the Bruneau River.

Downstream of Hot Creek the malacofauna is dominated numerically by two species: *Fluminicola fuscus* and *Gonidea angulata*. Conversely, the Bruneau Arm is dominated by *Gyraulus parvus* and *Vorticifex effusa* and no unionid bivalve molluscs were present (Stephenson *et al.* 2004). The non-native *Radix auricularia* was found only in the free-flowing river and the non-native *Potamopyrgus antipodarum* was found in both lotic and lentic habitats. The relative importance of molluscs in the river versus the reservoir follows habitat requirements of unionid mussels (Vaughn and Taylor 1999, Dillon 2000) and the comparative ecology of pulmonate and "prosobranch" snails (Brown *et al.* 1998, Brown and Johnson 2004). Pulmonate snails such as *Vorticifex effusa* and *Gyraulus parvus* are considered more tolerant of lentic systems with relatively eutrophic water quality whereas "prosobranchs" such as *Fluminicola fuscus* and unionids such as *Gonidea angulata* are more characteristic of lotic systems and relatively mesotrophic water quality.

Of note in the Bruneau River below Hot Creek are three species of intermediate relative abundance: *Gyraulus parvus*, *Physa gyrina*, and *Pyrgulopsis bruneauensis*. *Physa gyrina* occupies various habitat types and and is common throughout the area we studied. By contrast, based on our direct observations, both *G. parvus* and *Pyrgulopsis bruneauensis* are patchily distributed depending on the presence of suitable habitats.

The presence of *Potamopyrgus antipodarum* is of concern. This species is now the most abundant mollusc in parts of the middle Snake River (Richards *et al.* 2001) and can reach extremely high densities in some locations (Richards *et al.* 2004). The invasion of Bruneau River may be recent. Clark (1979) sampled two sites within the present study area in 1975, approx. 10 years prior to the invasion of the Snake River basin by this species, and failed to detect *P. antipodarum*. Similarly, surveys between Hot Creek and the Bruneau Arm completed between 1990 and 2005 also failed to detect and/or report the presence of *P. antipodarum* (Myler *et al.* 2007). Today the species is abundant in C. J. Strike Reservoir and appears to be moving upstream. The relatively recent establishment of *P. antipodarum* thus provides an opportunity to monitor its invasion and potential community level effects.

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